III. Remarks

Acceptance and favorable action therefor of the present application in view of this responsive Amendment is respectfully requested. (An authorized Credit Card Payment Form, covering the fee amount for the extended period of time and for the additional independent claim, is enclosed herewith.)

The status of the claims now pending are given hereinabove. Namely, claims 14, 19 and 20 are currently being amended, and independent claim 25 is being newly presented. Pending claims 1-12, 14-18, 21-24 were earlier withdrawn for purposes of examination.

The drawings were objected to for the reasons noted under item 6, on page 3 of the outstanding Office Action. In accordance with a review of the earlier submitted Substitute Specification as well as the drawings of the present application, a number of revisions were implemented in the drawings and, correspondingly, revisions were also implemented in the Specification to conform the same to the reference numeral changes being made to the drawings. Additionally, a number of minor informalities in the Specification are also being corrected. In this connection, also, applicants are submitting herewith a second Substitute Specification, as **Attachment A**, directed to the newly made revisions therein and, moreover, a marked-up version of the earlier-submitted Substitute Specification is also enclosed herewith, as **Attachment B,** which shows the location of as well as the actual changes being made to the earlier-submitted Specification, for the Examiner's convenience. It is submitted, the Substitute Specification includes only remedial/minor clarifying revisions. That is, the newly presented second Substitute Specification, it is submitted, does not raise the issue of new matter, either by the additions and/or deletions being made. A

review of the submitted marked-up version of the earlier-filed Substitute Specification clearly shows that the changes being made addresses each and every previously existing concern, as detailed under item 6, on page 3 of the outstanding Office Action.

The following brief discussion addresses a number of the changes being made to the Specification and, relatedly, to the drawings. (Incidentally, the page and line numbers referred to by the Examiner in item 6 on page 3 of the Office Action appears to relate to the originally-submitted Specification. However, the following discussion directs the same in terms of the earlier submitted Substitute Specification.)

Concerning the "Au ball bumps 110," on page 41, lines 21-22 of the earlier submitted Substitute Specification, correction was effected thereto so as to be consistent with the related showings in Fig. 10 of the drawings. The questioned "mounting lead 42" is now referred to in the Specification as "mounting lead 442" on page 59, line 12, of the new second Substitute Specification and is correspondingly shown in related Fig. 24 of the drawings. Concerning the drawing illustrations covering Figs. 22-30 of the drawings, the numerical references were renumbered in the 400+ digit range as is shown by the red-lined showings in the attachments to the accompanying paper entitled, "*Substitute Request for Approval to Amend the Drawings*". As indicated above, correspondingly, the Specification directed to these drawing illustrations was also revised in connection with the newly-submitted second Substitute Specification, accordingly.

Regarding the large number of listed reference numerals in item 6, on page 3 of the outstanding Office Action, please note that support is clearly found

in the Specification (now the second Substitute Specification). In this connection, please also note that most of those reference numerals were re-numbered in both the Specification and, correspondingly, in the drawings.

The reference numeral "5" in Fig. 1 relates to a lead terminal (see page 29, line 14, of the earlier filed Substitute Specification). As is clearly seen, all of the reference numerals in the drawings, as presently revised, are described in related portions of the Specification. As indicated above, the originally-employed two-digit numerical references in Figs. 22-30 are being converted to three-digit numerical references by simply adding "numeral 400" thereto. For example, numeral "1" now reads as "401," and original reference numeral "89" now reads as "489."

Where there was an original inadvertent omission in the description of reference numerals shown in the drawings, correction was effected thereto by the addition of descriptive language. It should be noted, the issue of new matter does not arise since those reference characters are, in fact, originally presented in the drawings with regard to particular element parts directed thereto and, in many instances, are also described elsewhere in the Specification such as with regard to other ones of the example illustrations of the present application. Accordingly, in view of the remedial action effected with the filing of the accompanying second Substitute Specification along with the changes being made to the drawings, any and all previously existing informalities directed thereto have now been rendered moot. Therefore, reconsideration and withdrawal of the standing objection is respectfully requested.

The title of the invention was amended so as to be more aptly descriptive of the invention to which the claims are directed. The new title, it is noted,

conforms to the suggested title in the Office Action and, therefore, acceptance of the same is respectfully requested.

By the Amendments presented hereinabove, claims 13, 19 and 20 were amended in consideration of overcoming the previously addressed concerns, namely, questions of definiteness, including to effect further clarification of the subject matter being covered thereby. Therefore, reconsideration and withdrawal of the previously standing rejection under 35 USC §112, second paragraph, is respectfully requested.

Regarding the invention called for in independent claim 13, a concern was raised with regard to the last subparagraph thereof. Namely, the last wherein clause, allegedly, is found to be confusing for the reasons noted under item 10 on page 4 of the Office Action. Accordingly, in consideration of a review thereof, the expression "said metallic layer is composed by bonding to each other ..." was accordingly revised to read instead as:

> said metallic layer is a composite metal comprised of a first precious metal layer provided at the front plane of said second electrode and a second precious metal layer adhered thereto by compression bonding provided at the front plane of said second metallic member.

Regarding a structure as called for in claim 13, metallic bonding is applied thereto as follows. In accordance with claim 13, the first electrode is formed on a front plane (i.e., the plane or principal surface whereon the circuit is formed) of a semiconductor substrate and is connected with a first metallic member; a second electrode, formed on the rear plane (the plane or principal surface on the back side) of the semiconductor substrate is connected with a second metallic member. A precious metal layer (e.g., practically, a vapor deposit film of Au or Ag) is formed on the second electrode and another precious metal layer (e.g., a Ag plated film) is formed on a surface of the second metallic member. Ag

particles or Ag sheet is inserted between the second electrode and the second metallic member, and the second electrode and a second metallic member are then metallic bonded by, for example, thermal-compression bonding or ultrasonic thermal-compression bonding. Claim 13, it is submitted, has been amended so as to avoid any such previously rendered concern as that alleged in item 10, on page 4, of the Office Action. Regarding the second part of the matter raised in item 10, on page 4 of the Office Action, the claim now clearly sets forth that at least two different precious metal layers are present.

Regarding the matter raised in item 11, on page 4 of the Office Action, the following brief discussion is directed thereto. The "semiconductor element", according to claim 13, it is submitted, does not contain an electrode on the front and rear (back) planes of a semiconductor substrate, rather, it contains a first electrode on the front plane and a second electrode on the rear plane (see claim 13, lines 4-6 thereof). Generally, with regard to vertical semiconductor active elements such as a diode, a MOS transistor, a bipolar transistor, and so forth, the plane (the principal surface) of the semiconductor substrate where a pn or np junction associated with such element is provided is designated as a front plane, and the opposing, reverse or back plane thereto is designated as the rear plane (or back plane). The electrode (of such a semiconductor element) that is formed on the front plane is designated as the first electrode according to claim 13 as well as with regard to other claims, and the electrode that is formed on the rear plane is designated as a second electrode.

Regarding independent claim 19, any previously rendered concerns have been overcome in view of the amendments presented hereinabove. In the semiconductor device according to claim 19, the bonding region basically relates

to the area where the Au bump is geometrically in contact with the, for example, aluminum pad. In accordance with the scheme called for in independent claim 19, at least 80% of an area of a Au/Al bonding region is contacting a corresponding Au bump, and that the bonding region associated with a pad is made of an Au/Al alloy layer in the thickness direction. Such is now clearly presented with regard to the last "wherein" clause of independent 19.

Clarification was also effected with regard to independent claim 20 in consideration or removing any and all previously existing concerns thereto. In that regard, also, the convention regarding the numerical recitation of the first and second metallic members was interchanged so as to conform to the electrode recitation sequence employed with regard to the other pending claims.

Regarding the matter raised in item 14, on page 5 of the Office Action, the following brief discussion is directed thereto. In the case of a transistor type active element, an electrode where the main current associated with the source electrode in the case of a MOS transistor (or emitter electrode in the case of a bipolar transistor) flows and a gate electrode to control the main current are both formed on the front plane of the semiconductor substrate. On the rear or backplane thereof, a drain (or collector) electrode is formed. The control electrode is typified by a gate electrode and the "third metallic member" of claim 20 is connected to the control electrode. In accordance with the present invention, the "control electrode" is formed on the same front plane as that electrode which is associated with the flow of main current such as the source (or emitter) electrode. That electrode, associated with the main current flow occupies a large part of the front plane while the control electrode occupies a relatively small part of the front plane.

Newly added independent claim 25 also covers a structure inclusive of that called for in claim 20, as now amended, however, it omits the expression "and planes of said first and third metallic members opposite to said chip", contained in the last "wherein" clause of claim 20. Since newly-presented claim 25 also covers a scheme as that according to claim 20, it should also be included in the claims of the elected species. Regarding the concerns raised under items 15, 16, 17 and 18, on page 5 of the Office Action, clarifying revisions were implemented therein, accordingly. Corresponding changes were also implemented with regard to the newly-presented independent claim 25.

According to the outstanding Office Action, claims 13 and 19, "insofar as being definite," were rejected under 35 USC §103(a) over the combination of Kasem et al (US 6,249,041) in view of Nakamura (JP 1-266752). It will be shown, hereinbelow, the invention according to claims 13 and 19, as now amended, could not have been rendered obvious therefrom. Therefore, insofar as presently applicable, this rejection is traversed and reconsideration and withdrawal of the same is respectfully requested.

Kasem et al disclosed a MOSFET package structure. With regard to this, Kasem et al shows a lead frame and a chip that are bonded via an adhesive layer (e.g., 19, 23). The adhesive layer may be composed of Ag paste, soldering bumps, other conductive adhesive agents and so forth.

Nakamura et al disclosed a structure in which an aluminum (Al) electrode of the chip is bonded to Cu (copper) leads by a thermal-compression method via Au bumps which are formed by plating.

As stated earlier, Kasem et al taught a scheme in which a lead frame and electrodes of the chip are directly bonded by a conductive adhesive layer or

soldering bumps. However, the bonding scheme taught by Kasem et al, it is submitted, cannot be performed directly on an aluminum electrode. This is because when aluminum material is used as the electrode, the surface of that electrode is necessarily covered with a solid insulating oxide film. As a result, therefore, a desired level of conduction cannot be achieved if one were to employ a conductive adhesive agent under such a condition. Moreover, soldering would also not be as effective because the surface of the aluminum electrode does not become wetted with solder due to the presence of the oxide film over the aluminum electrode.

In order to realize a structure according to Kasem et al, plating on the surface of the Al electrode with a precious metal is necessary. The present invention differs from Kasem et al at least in a point that gold (Au) bumps are used for bonding the Al electrode to a lead frame and, also, in a point that the Au bumps are directly bonded to the Al electrode to form a Au/Al compound. Moreover, it is noted that Kasem et al are silent regarding the featured aspect in which the plural bondings (e.g., Au bumps) are formed on the main current electrode (e.g., the source electrode) in a uniform arrangement.

Nakamura et al disclosed a scheme in which Au bumps are used for bonding the Al electrode 2 with leads 4. However, details on the bonding condition effected between that of the Al electrode 2 with Au bump 3 are not given. Regarding the bonding of the Au bumps with the lead, Nakamura et al, it is observed, describes the use of Sn plating, however, Nakamura et al are silent on use of precious metal for plating.

In contradistinction with Nakamura et al's teachings, the present invention according to claims 13 and 19 differs therefrom in that the bonding of Al

electrode with a Au bump is effected by forming a Au/Al compound, the surface of the lead to be bonded with the Au bump is plated with a precious metal, the Au bump and the lead are bonded to each other by metal bonding with precious metals, and plural Au bumps are formed on a single electrode.

As described above, none of the references disclosed or suggested the invention according to claims 13, 19 or, for that matter, with regard to claims 20 and 21. Moreover, even if one of ordinary skill would have attempted to combine the teachings of Kasem et al and Nakamura et al, the invention would still not have been realizable therefrom. If one of ordinary skill would have attempted to employ Nakamura et al's bonding scheme into Kasem et al's package structure, a number of technical problems would arise.

In the case where Au plated bumps are formed on the chip side (i.e., the bump is bonded to the lead), bonding the Au bump directly to the copper (Cu) lead becomes difficult. It is necessary to perform Sn plating on the lead to form a Au/Sn alloy for bonding. However, Sn material at portions other than at the bonding portion ends up remaining as is, and any such remaining Sn will lead to problems such as peeling off of the molding resin due to melting of any remaining Sn layer during a secondary mounting step after forming a product. Therefore, it becomes technically quite difficult to apply the bonding scheme taught by Nakamura et al to the formation of the package structure of Kasem et al.

As a second example of the difficulties that would be involved in employing Nakamura et al's bonding scheme to a structure as that taught by Kasem et al, let us examine a case in which the Au plated bumps are formed on the lead side (i.e., the bump is bonded to the Al electrode). In accordance with

this, in order to effectively perform bonding by forming a Au/Al alloy layer such as by thermal-compression, it is necessary to heat the bonding portion to approximately 300°C, and to make the bump be deformed significantly by adding a heavy load thereto. However, when attempting to bond plural portions simultaneously, a large thermal stress proportional to the distances between the bonding portions develops due to the difference in the thermal expansion coefficients between that of the chip and that of the lead. As a result, therefor, the problem of breakage such as at the bonding boundary of Au/Al develops. If the height of the bump is high enough, the thermal stress can be moderated. However, the bonding at the boundary of Au/Al becomes insufficient and, as a result, a breakage will occur because of insufficient strength at the bonded portion. If the bonding temperature is lowered the thermal stress will be decreased. However, the strength at the bonded portion at the Au/Al boundary becomes weakened which also would lead to breakage resulting from insufficient strength of the bonded portion. It is submitted, it would be technically difficult to apply a bonding structure as taught by Nakamura et al to the scheme taught by Kasem et al.

At least for the above reasons, one of ordinary skill would not have attempted to employ the teachings of Nakamura et al in a structure as taught by Kasem et al. However, assuming, *arguendo*, that one of ordinary skill would have attempted to combine the teachings of both, there still would not have been realized a semiconductor device as that called for in claims 13 and 19 and, even with regard to claims 20 and 25. In fact, even if one of ordinary skill would have attempted to employ, also, Bonshihara et al in combination with Kasem et al and Nakamura et al, the invention would still not have been realizable therefrom.

Bonshihara et al (JP 57-103342) disclosed a schemed structure in which a lead is base-plated with a precious metal, and Sn is plated thereon for bonding. The lead is bonded to the Au bumps of the chip by forming a Au/Sn alloy. (It is submitted, Bonshihara et al was improperly applied in the body of the rejection since it was not cited in the actual rejection. On this basis, Bonshihara et al's disclosure is ineffectual in terms of this rejection. However, assuming, *arguendo,* that Bonshihara et al was properly included in the actual rejection made of the claims, the invention according to claims 13 and 19, as now amended, is still clearly patentable over the three disclosures).

Although Bonshihara et al disclosed plating of the lead with a precious metal, Bonshihara et al, it is observed, further requires a Sn to be plated thereon. The precious metal layer in Bonshihara et al is formed in order to prevent the growth of a "whisker" from the Sn layer, and bonding is performed by Au/Sn reaction.

In accordance with the present invention, the precious metal layer is formed on the outermost surface of the lead so as to insure the bonding of the lead with a Au bump. Accordingly, the present invention differs from Bonshihara et al in at least the composition at the surface of the lead. An objective with regard to formation of the precious metal layer, according to the present disclosure, also differs from that taught by Bonshihara et al.

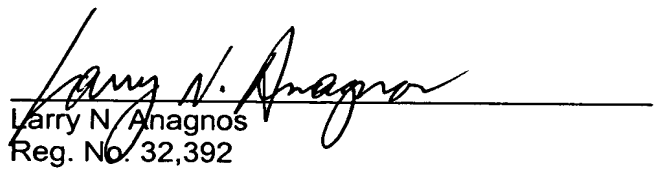
Therefore, in view of the amendments presented hereinabove together with these accompanying remarks reconsideration as well as favorable action therefor on the presenting pending claims and an early formal Notification of Allowability of the above-identified application is respectfully requested.

A marked-up version showing changes made to the earlier-filed

Substitute Specification is enclosed herewith as Attachment B.

To the extent necessary, applicants petition for an extension of time under 37 CFR §1.136. Please charge any shortage in the fees due in connection with the filing of this paper, including extension of time fees to the Deposit Account of Antonelli, Terry, Stout & Kraus, LLP, Dep. Acct. No. 01-2135 (503.38097X00), and please credit any excess fees to such deposit account.

Respectfully submitted,
ANTONELLI, TERRY, STOUT & KRAUS, LLP



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